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DERATED APPLICATION OF PARTS
FOR ESD SYSTEMS DEVELOPMENT

Rome Air Development Center
Systems Reliability and Engineering Branch
Griffiss AFB, New York 13441

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AIR FORCE SYSTEMS COMMAND
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HANSCOM AFB, MASSACHUSETTS 01731

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## REVIEW AND APPROVAL

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

Eugene C. Kalkman

EUGENE C. KALKMAN
Chief Engineer and Assistant
Deputy for Technical Operations
Deputy for Acquisition Logistics
and Technical Operations

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This document establishes part derating to be implemented on AFSC/ESD contracts. These criteria were prepared for ESD by RADC/RB and reflect the design derating criteria prepared for them under contract F30602-81-V-0073, as well as other RADC data. Established derating values for the majority of parts in MIL-HDBK-217, and a suggested approach for verification of derating parameters are included. Recommendations for improving, clarifying, or tailoring these iterim derating criteria should be addressed to: Electronic Systems Division, Attn: ALK, Hanscom Air Force Base, Bedford, Massachusetts 01731 (cont'd)

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## SECTION 1

## INTRODUCTION

1.1 Purpose. The purpose of this document is to improve equipment reliability by requiring a conservative design approach using a realistic derating of parts. Derating is the practice of limiting electrical, thermal, and mechanical stresses on parts to levels below their specified or proven capability limits.

1.2 Design Requirements. The design application of parts will be derated in accordance with the criteria of a government approved contractor derating standard or this document. If the criteria of a contractor's standard are consistent with the specified requirements of this document, the contractor standard will be the contractual requirement; if not, this document will be the contractual requirement. The methods and specific wording for making derating a contractual requirement are defined in Appendix A.

The derating criteria throughout section 2 of this document, and summarized in Appendix C, are specified in three levels. The appropriate level must be selected and specified based on the following criteria:

a. The operational mission necessitates very few outages.

b. The system is unaccessible for repair.

c. System failures can be catastrophic in terms of personnel safety or very costly damage to equipments or facilities would occur.

d. Support costs (i.e., life cycle costs) must be minimized.

e. Certain applications have size, weight or cooling limitations which necessitate less derating.

f. If an application has less than MIL SPEC environments, greater temperature derating is practical.

1.3 Verification Requirements. Contractors must perform adequate engineering analysis and testing to verify compliance with the derating requirements.

Formal verifications of derating requirements will be performed, monitored, and reported. The methods for making the verification a contractual requirement are defined in Appendix A, paragraph 3. Verification methods are defined in Appendix B.

SECTION 2

DERATING CRITERIA

## 2.1 Microcircuit Derating Criteria

2.1.1 General - Microcircuits can be generally characterized as a group of devices that includes such items as monolothic, multichip, film and hybrid microcicuits, microcircuit arrays and the elements from which the circuits and arrays are formed. The derating levels in this section are based upon analysis of user data, stress relationships and reliability history.

2.1.2 Microcircuit Types - For this criteria, microcircuits will be divided into three major categories. The categories are:

- o Linear Devices (Bipolar & MOS)
- o Digital Devices (Bipolar & MOS)
- o Hybrid Devices (Attached Element, Thick Film, Thin Film)

### 2.1.2.1 Linear Microcicuits

- o Application - MOS devices are susceptible to electrostatic discharge and precautions should be take. Design margins for linear circuits should be used, such as: -20% for gain and +50% for offset voltages and currents.
- o Derating - The principal stress parameters and levels of derating are shown in Table 2.1-1. The derating levels apply to both bipolar and MOS linear microcircuits.

TABLE 2.1-1: DERATING FOR LINEAR MICROCIRCUITS (BIPOLAR AND MOS)

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| SUPPLY VOLTAGE (% OF RATED VALUE) | 70 (1) | 80 | 80 |
| INPUT VOLTAGE (% OF RATED VALUE) | 60 | 70 | 70 |
| OUTPUT CURRENT (% OF RATED VALUE) | 70 | 75 | 80 |
| MAXIMUM JUNCTION TEMPERATURE (°C) | 80 | 95 | 105 |

(1) Designing below 80% of the supply voltage may operate the device below recommended operating voltages

#### 2.1.2.2 Digital Microcircuits

- Application - MOS devices are susceptible to electrostatic discharge and precautions should be taken. For bipolar digital devices, supply voltage device deviation from the specified nominal will shift internal bias points which when coupled with thermal effects can cause erratic performance. Design precautions should be taken. Design margins should also be used for input leakage current (+100%), fan-out (-20%) and frequency (-10%).

- Derating - The principal stress parameters and levels of derating are shown in Table 2.1-2. The derating levels apply to bipolar and MOS digital microcircuits as shown.

TABLE 2.1-2: DERATING FOR DIGITAL MICROCIRCUITS (BIPOLAR AND MOS)

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| SUPPLY VOLTAGE (BIPOLAR) (1) | +/-3% | +/-5% | +/-5% |
| SUPPLY VOLTAGE (MOS) (% OF RATED VALUE) | 70(2) | 85 | 85 |
| FREQUENCY (BIPOLAR) (OF ABSOLUTE MAXIMUM) | 80 | 90 | 95 |
| FREQUENCY (MOS) (OF MAXIMUM SPECIFIED) | 80 | 80 | 90 |
| OUTPUT CURRENT (MOS & BIPOLAR) (% OF RATED VALUE (3) | 80 | 85 | 90 |
| MAXIMUM JUNCTION TEMPERATURE (°C) (MOS & BIPOLAR) | 85 | 100 | 110 |

(1) Tighten tolerance from nominal value for bipolar.

(2) Designing below 80% of the supply voltage may cause operation of the device below the recommended operating voltage.

(3) Reducing fan-out may increase part count, which in turn increases equipment failure rate. Adjustment should be allowed to prevent this occurrence.

2.1.2.3 Hybrid Microcircuits

- Description - Hybrid circuits are usually composed of attached elements such as integrated circuit, transistor, capacitor and/or resistor chips mounted on a common substrate. This technology combines elements into a high density package to decrease volume and sometimes power. The hybrid circuits may also use thick or thin films as interconnections and resistive elements. The primary failure modes are failures of active elements (integrated circuit or transistor chips) and interconnection faults.

- Application - Some hybrid circuits are susceptible to electrostatic discharge and precautions should be taken. Supply voltage deviation from the specified nominal wil shift internal bias points which, when combined with thermal effects, can cause erratic performance.

- Derating - The attached elements must be derated as shown in this document for the individual devices. For unique hybrids such as crystal oscillators or LED displays, the specific derating values for microcircuits and LED diodes need to be followed. In general, hybrid derating should follow the derating factors shown in Table 2.1-3.

TABLE 2.1-3: DERATING FOR HYBRID DEVICES

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) | 85 | 100 | 110 |
| THICK FILM POWER DENSITY (1) | 50 WATTS/IN$^2$ | 50 WATTS/IN$^2$ | 50 WATTS/IN$^2$ |
| THIN FILM POWER DENSITY (1) | 40 WATTS/IN$^2$ | 40 WATTS/IN$^2$ | 40 WATTS/IN$^2$ |

(1) For every degree C above 100° case temperature, derate the power density 1 Watt/in$^2$ below the values shown.

2.2 Transistor Derating Criteria

2.2.1 General - The transistor area can be generally characterized as groups of devices that include switching, power. field-effect, microwave and thyristors. The basic applications include amplification and switching. The derating levels are based upon analysis of user data, stress relationships and reliability history. Junction, case or other temperature parameters should be calculated using the methods described in MIL-HDBK-251 (Reliability Design Thermal Applications).

2.2.2 Transistor Types - For this guideline, transistors are divided into three major categories with subcategory descriptions. The categories and subcategories are:

- o Bipolar Silicon Transistors (NPN or PNP)
  - Low power devices (<5W @ $T_C$=25°C)
  - High power devices (>5W @ $T_C$=25°C)
  - RF devices
  - Darlington devices
  - Microwave devices
- o Unijunction Devices (Not recommended for new designs)
- o Field Effect Transistors (N channel or P channel)
  - Junction devices
  - MOS devices
  - GaAs Microwave devices
- o Thyristors
  - SCR (Silicon Controlled Rectifier) devices
  - TRIAC devices

2.2.2.1 Bipolar Silicon Transistors

- o Application - For new designs, germanium and unijunction devices shall not be considered. Also, the sum of the anticipated transient voltage peaks and the operating voltage peaks shall not exceed the derating voltage levels.

- o Derating - High junction temperature is the most destructive stress for transistors; therefore, this parameter along with voltage breakdown, power and safe operating area need to be derated. Specific derating levels are shown in Table 2.2-1.

TABLE 2.2-1: DERATING FOR BIPOLAR SILICON TRANSISTORS

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) | 95 | 105 | 125 |
| POWER DISSIPATION (% OF RATED VALUE) | 50 | 60 | 70 |
| LOW POWER DEVICE BREAKDOWN VOLTAGE (% OF RATED VALUE) | 60 | 70 | 70 |
| HIGH POWER DEVICE SAFE OPERATING AREA (1) (% OF RATED VALUE) | 70 $V_{ce}$<br>60 $I_c$ | 70 $V_{ce}$<br>60 $I_c$ | 70 $V_{ce}$<br>60 $I_c$ |

(1) The safe operating area is a curve running parallel to the one specified in the JAN specification or vendor prepared specification at the stated percentage of the rated values.

2.2.2.2 Field-Effect Transistors

- o Application - The field-effect transistor is a voltage controlled device which can perform the switching or amplification function and has very high input impedance. The GaAS device can withstand higher working temperatures due to its larger band gap than does the silicon microwave device.

- o Derating - The derating levels are shown in Table 2.2-2.

TABLE 2.2-2: DERATING FOR FIELD-EFFECT TRANSISTORS

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) | 95 | 105 | 125 |
| POWER DISSIPATION (% OF RATED VALUE) | 50 | 60 | 70 |
| BREAKDOWN VOLTAGE (% OF RATED VALUE) | 60 | 70 | 70 |

2.2.2.3 Thyristors

- Application - The thyristor is composed of bistable semiconductor devices with three or more junctions that can be switched from the "off" state to the "on" state or vice versa. The design must have hard gate turn-on levels because marginal or slow gate drive can cause device failure.

- Derating - The chief failure forcing functions for thyristors are excessive junction temperature (a function of forward current) and voltage breakdown. The derating levels are shown in Table 2.2-3.

TABLE 2.2-3: DERATING FOR THYRISTORS

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) | 95 | 105 | 125 |
| ON-STATE CURRENT ($I_t$) (% OF RATED VALUE) | 50 | 70 | 70 |
| OFF-STATE VOLTAGE (VDM) (% OF RATED VALUE) | 70 | 70 | 70 |

## 2.3 Diode Derating Criteria

2.3.1 General - The categories of diodes considered in this section include switching, power rectifiers, reference, transient suppressors, microwave and LED devices. The derating levels are based upon analysis of user data, stress relationships and reliability history.

2.3.2 Diode Types - For this guideline, diodes will be divided into six major categories with subcategory descriptions. The categories and subcategories are:

- Axial Lead Diodes (small signal, switching)
  - Silicon devices
  - Schottky devices
  - PIN devices

- Power Rectifiers
  - Axial lead rectifiers (standard and fast recovery)
  - Stud rectifiers (silicon and Schottky)
  - High voltage and current rectifiers
- Voltage Reference and Zener Diodes
- Transient Suppressor Diodes
- Microwave Diodes
- LED (Light Emitting Diodes)

### 2.3.2.1 Axial Lead Diodes

- Application - Germanium diodes are not recommended for new designs. For improved reliability, metallurgically bonded and hermetically sealed diodes are preferred.

- Derating - High junction temperature is the most destructive stress for diodes. For silicon switching and signal diodes, temperature, voltage and current are principal stress parameters. For Schottky and PIN diodes, use power derating in place of current derating. Specific derating levels are shown in Table 2.3-1.

TABLE 2.3-1: DERATING FOR AXIAL LEAD (SMALL SIGNAL/SWITCH) DIODES

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) (ALL DIODES) | 95 | 105 | 125 |
| REVERSE VOLTAGE (% OF RATED VALUE) (ALL DIODES) | 70 | 70 | 70 |
| AVERAGE FORWARD CURRENT (% OF RATED VALUE) (SILICON DIODES) | 50 | 65 | 75 |
| POWER DISSIPATION (% OF RATED VALUE) (SCHOTTKY AND PIN) | 50 | 60 | 70 |

2.3.2.2 Power Rectifiers

o Derating - For power rectifiers including high voltage and current rectifiers, temperature is the principal stress parameter. Derating levels are shown in Table 2.3-2.

TABLE 2.3-2: DERATING FOR POWER RECTIFIERS

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) | 95 | 105 | 125 |
| REVERSE VOLTAGE (% OF RATED VALUE) | 70 | 70 | 70 |
| AVERAGE FORWARD CURRENT (% OF RATED VALUE) | 50 | 65 | 75 |

2.3.2.3 Voltage Reference and Regulator Diodes

o Derating - For voltage regulator diodes temperature and power dissipation are the principal stress parameters. Derating levels are shown in Table 2.3-3.

TABLE 2.3-3: DERATING FOR VOLTAGE REFERENCE AND REGULATOR DIODES

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) (ALL DIODES) | 95 | 105 | 125 |
| POWER DISSIPATION (% OF RATED VALUE) (REGULATOR) | 50 | 60 | 70 |
| CURRENT ($I_{zt}$) (REFERENCE) | FIXED TEST CURRENT | FIXED TEST CURRENT | FIXED TEST CURRENT |

2.3.2.4 Transient Suppressor Diodes

o Derating - For transient suppressor diodes, temperature, current and power dissipation are the principal stress parameters. Derating levels are shown in Table 2.3-4.

TABLE 2.3-4: DERATING FOR TRANSIENT SUPPRESSOR DIODES

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) | 95 | 105 | 125 |
| AVERAGE CURRENT (% OF RATED VALUE) | 50 | 65 | 75 |
| POWER DISSIPATION (% OF RATED VALUE) | 50 | 60 | 70 |

### 2.3.2.5 Microwave Diodes

- o Application - Microwave design involves distributed constants; therefore the diode, package, parasitics, interconnections and other components must be considered as a single unit. This often prevents consideration of derating as a separate variable.

- o Derating - The principal stress factors for microwave diodes are junction temperature, power dissipation, and voltage. Derating levels are shown in Table 2.3-5.

TABLE 2.3-5: DERATING FOR MICROWAVE DIODES

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) | 95 | 105 | 125 |
| REVERSE VOLTAGE (% OF RATED VALUE) | 70 | 70 | 70 |
| POWER DISSIPATION (% OF RATED VALUE) | 50 | 60 | 70 |

### 2.3.2.6 LED (Light Emitting Di( s)

- o Derating - The principal stress factors for LED devices are temperature and current. Derating levels are shown in Table 2.3-6.

TABLE 2.3-6: DERATING FOR LED (LIGHT EMITTING DIODES)

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) | 95 | 105 | 110 |
| AVERAGE FORWARD CURRENT (% OF RATED VALUE) | 50 | 65 | 75 |

## 2.4 Resistor Derating Criteria

2.4.1 General - This section supplies the derating levels and application guidelines for resistors. The principal stress parameters in derating resistors is the hot spot temperature, which is the sum of the ambient temperature and the temperature due to the dissipated power. Therefore, decreasing the ambient temperature or the power dissipation factor will extend the lifetime.

2.4.2 Resistor Types - The resistor types that will be covered in this section are defined by the following Military Specifications:

COMPOSITION, FIXED

| | |
|---|---|
| MIL-R-39008 | Resistors, Fixed, Composition (Insulated), Established Reliability (ER), (Style RCR) |

FILM, FIXED

| | |
|---|---|
| MIL-R-11804 | Resistors, Fixed, Film, (Power Type), (Style RD) |
| MIL-R-22684 | Resistors, Fixed, Film, Insulated, (Style RL) |
| MIL-R-39017 | Resistors, Fixed, Film, Insulated, ER, (Style RLR) |
| MIL-R-55182 | Resistors, Fixed, Film, ER, (Style RNR) |
| MIL-R-55342 | Resistors, Fixed, Film, Chip, ER, (Style RM) |

NETWORK, FILM, FIXED

| | |
|---|---|
| MIL-R-83401 | Resistor Network, Fixed, Film (Style RZ) |

WIREWOUND, FIXED

| | |
|---|---|
| MIL-R-26 | Resistors, Fixed, Wirewound (Power Type), (Style RW) |
| MIL-R-18546 | Resistors, Fixed, Wirewound (Power Type, Chassis Mounted), (Style RE) |
| MIL-R-39005 | Resistors, Fixed, Wirewound (Accurate), ER, (Style RBR) |
| MIL-R-39007 | Resistors, Fixed, Wirewound (Power Type), ER, (Style RWR) |
| MIL-R-39009 | Resistors, Fixed, Wirewound (Power Type, Chassis Mounted), ER, (Style RER) |

NON-WIREWOUND, VARIABLE

| | |
|---|---|
| MIL-R-94 | Resistors, Variable, Composition, (Style RV) |
| MIL-R-22097 | Resistors, Variable, Non-wirewound (Lead Screw Actuated), (Style RJ) |
| MIL-R-23285 | Resistors, Variable, Non-wirewound (Style RVC) |
| MIL-R-39023 | Resistors, Variable, Non-wirewound, Precision, (Style RQ) |
| MIL-R-39035 | Resistors, Variable, Cermet, or Carbon Film (Lead Screw Actuated) ER, (Style RJR) |

WIREWOUND, VARIABLE

| | |
|---|---|
| MIL-R-19 | Resistors, Variable, Wirewound (Low Operating Temperature), (Style RA) |
| MIL-R-22 | Resistors, Variable, Wirewound (Power Type), (Style RP) |
| MIL-R-12934 | Resistors, Variable, Wirewound, Precision, (Style RR) |
| MIL-R-27208 | Resistors, Variable, Wirewound (Lead Screw Actuated), (Style RT) |
| MIL-R-39002 | Resistors, Variable, Wirewound, Semi-Precision, (Style RK) |
| MIL-R-39015 | Resistors, Variable, Wirewound, (Lead Screw Actuated), ER, (Style RTR) |

THERMISTOR

| | |
|---|---|
| MIL-T-23648 | Thermistor (Thermally Sensitive Resistor), Insulated, (Style RTH) |

2.4.2.1 Fixed Composition Resistors

- Application - The voltage coefficient for resistors below 1000 Ohms is not controlled by specification and these resistors should not be used in circuits which are sensitive to this parameter.

- Derating - Ambient temperature and power are the principal stress parameters for fixed composition resistors. The derating levels are shown in Table 2.4-1.

TABLE 2.4-1: DERATING FOR RESISTORS, FIXED COMPOSITION DEFINED BY MIL-R-39008

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| POWER (% OF RATED VALUE) | 50 | 50 | 50 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 30 | 30 | 30 |

2.4.2.2 Fixed Film Resistors

- Application - These resistors are recommended for use where very close tolerances are not required and where the composition type resistors do not provide the needed accuracy or stability. Resistance values decrease at frequencies of 100 MHz or above. MIL-R-22684 is not recommended for new designs.

- Derating - Ambient temperature and power are the principal stress parameters for fixed film resistors. The maximum continuous working voltage specified for MIL-R-22684 and MIL-R-39019 should not be exceeded regardless of the calculated rated voltage on the basis of power rating. For MIL-R-55182 type the peak power dissipated should not exceed four times the maximum rating of the resistor. The derating levels are shown in Table 2.4-2.

TABLE 2.4-2: DERATING FOR RESISTORS, FIXED FILM DEFINED BY MIL-R-11804, MIL-R-22684, MIL-R-39017, MIL-R-55182, MIL-R-55342

| | | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|---|
| POWER (% OF RATED VALUE) | ALL RESISTORS | 50 | 50 | 50 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | MIL-R-11804 | 75 | 75 | 75 |
| | MIL-R-22684 | 40 | 40 | 40 |
| | MIL-R-39017 | 40 | 40 | 40 |
| | MIL-R-55182 | 25 | 25 | 25 |
| | MIL-R-55342 | 25 | 25 | 25 |

2.4.2.3 Fixed Network Film Resistors

- Application - these resistors are stable with respect to time, temperature and humidity. When used in high frequency circuits, 200 MHz and above, the resistance will be reduced.

- Derating - Ambient temperature and power are the principal stress parameters for fixed network film resistors. The derating levels are shown in Table 2.4-3.

TABLE 2.4-3: DERATING FOR RESISTORS, NETWORK FIXED FILM DEFINED BY MIL-R-83401

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| POWER (% OF RATED VALUE) | 50 | 50 | 50 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 25 | 25 | 25 |

2.4.2.4 Fixed Wirewound Resistors

- Application - These resistors are used where very close tolerance, long life and a high degree of temperature stability is required.

- Derating - Ambient temperature and power are the principal stress parameters for fixed wirewound resistors. For MIL-R-39009 type resistors the chassis-area is a critical parameter. With a reduction in the chassis-area, the power must be derated. The derating levels are shown in Table 2.4-4.

TABLE 2.4-4: DERATING FOR RESISTORS, FIXED WIREWOUND DEFINED BY MIL-R-26, MIL-R-18546, MIL-R-39005, MIL-R-39007, MIL-R-39009

| | | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|---|
| POWER (% OF RATED VALUE) | ALL RESISTORS | 50 | 50 | 50 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | MIL-R-26 | 160 | 160 | 160 |
| | MIL-R-18546 | 125 | 125 | 125 |
| | MIL-R-39005 | 10 | 10 | 10 |
| | MIL-R-39007 | 125 | 125 | 125 |
| | MIL-R-39009 | 125 | 125 | 125 |

### 2.4.2.5 Variable Non-wirewound Resistors

- Application - For this resistor group, the conducting element determines the maximum operating temperature and power rating. MIL-R-94 type resistors should not be used at potential to ground greater than 500V peak. Secondary insulation is needed for MIL-R-22097 and MIL-R-39035 resistors for voltages 250 volts rms or higher between the resistor and the ground surface. MIL-R-30923 type resistors are not recommended for new designs due to contact resistance variations. MIL-R-23285 type resistors are suitable for potentiometer applications where high precision is not required.

  Derating - Ambient temperature and power are the principal stress parameters for variable non-wirewound resistors. The derating levels are shown in Table 2.4-5.

TABLE 2.4-5: DERATING FOR RESISTORS, VARIABLE NON-WIREWOUND DEFINED BY MIL-R-94, MIL-R-22097, MIL-R-23285, MIL-R-39023, MIL-R-39035

| | | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|---|
| POWER (% OF RATED VALUE) | MIL-R-94 | 30 | 50 | 50 |
| | MIL-R-22097 | 30 | 50 | 50 |
| | MIL-R-23285 | 50 | 50 | 50 |
| | MIL-R-39023 | NR* | 50 | 50 |
| | MIL-R-39035 | 30 | 50 | 50 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | MIL-R-94 | 35 | 25 | 25 |
| | MIL-R-22097 | 45 | 35 | 35 |
| | MIL-R-23285 | 20 | 20 | 20 |
| | MIL-R-39023 | NR | 15 | 15 |
| | MIL-R-39035 | 45 | 35 | 35 |

*NR - NOT RECOMMENDED

### 2.4.2.6 Variable Wirewound Resistors

- Application - This resistor group is used as rheostats or voltage dividers. For MIL-R-22 type resistors operation at ambient temperatures greater than 125°C can damage the resistor. In addition, the resistor is unenclosed and can be effected by environmental conditions such as moisture. Secondary insulation is needed for MIL-R-27208 and MIL-R-39015 for voltages higher than 250 volts rms between the resistor and ground surface. MIL-R-12934 and MIL-R-39002 type resistors are not recommended for Level I application due to the contact resistance variation.

- Derating - Ambient temperature and power are the principal stress parameters for variable wirewound resistors. The derating levels are shown in Table 2.4-6.

TABLE 2.4-6: DERATING FOR RESISTORS, VARIABLE WIREWOUND DEFINED BY MIL-R-19, MIL-R-22, MIL-R-12934 MIL-R-27208, MIL-R-39002, MIL-R-39015

| | | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|---|
| POWER (% OF RATED VALUE) | MIL-R-19 | 30 | 50 | 50 |
| | MIL-R-22 | NR* | NR | 70 |
| | MIL-R-12934 | NR | 50 | 50 |
| | MIL-R-27208 | 30 | 50 | 50 |
| | MIL-R-39002 | NR | 50 | 50 |
| | MIL-R-39015 | 30 | 50 | 50 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | MIL-R-19 | 45 | 35 | 35 |
| | MIL-R-22 | NR | NR | 10 |
| | MIL-R-12934 | NR | 20 | 20 |
| | MIL-R-27208 | 45 | 35 | 35 |
| | MIL-R-39002 | NR | 20 | 20 |
| | MIL-R-39015 | 45 | 35 | 35 |

*NR - NOT RECOMMENDED

2.4.2.7 Thermistor (Thermally Sensitive Resistor)

- Application - Operation above the maximum hot spot temperature will produce permanent resistance changes. Use current limiting resistors to prevent the negative coefficient type from going into thermal runaway. Never exceed the maximum current or power ratings.

- Derating - Ambient temperature and power are the principal stress parameters for thermistor resistors. The derating levels are shown in Table 2.4-7.

TABLE 2.4-7: DERATING FOR THERMISTORS
DEFINED BY MIL-T-23648

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| POWER (% OF RATED VALUE) | 50 | 50 | 50 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 20 | 20 | 20 |

## 2.5 Capacitor Derating Criteria

2.5.1 General - This section supplies the derating levels and application guidelines for capacitors. The principal stress factors for capacitors are temperature (including the capacitor's case temperature rise from AC loading), and DC and/or AC voltage. Therefore, decreasing the temperature or the voltage will extend the lifetime.

2.5.2 Capacitor Types - The capacitor types that will be covered in this section are defined by the following Military Specifications:

PAPER/PLASTIC FILM

| | |
|---|---|
| MIL-C-11693 | Capacitors, Fixed, Paper, Metallized Paper, Metallized Plastic, RFI Feed-Thru, Established Reliability and Non-Established Reliability (Style CZR and CZ) |
| MIL-C-19978 | Capacitors, Fixed, Plastic (or Paper-Plastic,) Established and Non-Established Reliability, (Style CQR and CQ) |
| MIL-C-39022 | Capacitors, Fixed, Metallized, Paper-Plastic Film or Plastic Film Dielectric, Established Reliability, (Style CHR) |
| MIL-C-55514 | Capacitors, Plastic, Metallized Plastic, Established Reliability, (Style CFR) |
| MIL-C-83421 | Capacitors, Super-Metallized Plastic, Established Reliability, (Style CRH) |

MICA

| | |
|---|---|
| MIL-C-10950 | Capacitors, Fixed, Mica, Button Style, (Style CB) |
| MIL-C-39001 | Capacitors, Fixed, Mica, Established Reliability, (Style CMR) |

GLASS

| | |
|---|---|
| MIL-C-23269 | Capacitors, Fixed, Glass, Established Reliability (Style CYR) |

CERAMIC

| | |
|---|---|
| MIL-C-20 | Capacitors, Fixed, Ceramic (Temperature Compensating), (Style CCR) |
| MIL-C-11015 | Capacitors, Fixed, Ceramic (General Purpose), (Style CK) |
| MIL-C-39014 | Capacitors, Fixed, Ceramic (General Purpose), Established Reliability, (Style CKR) |

ELECTROLYTIC

| | |
|---|---|
| MIL-C-62 | Capacitors, Fixed, Electrolytic (DC, Aluminum, Dry Electrolyte, Polarized), (Style CE) |
| MIL-C-39003 | Capacitors, Fixed, Electrolytic, Tantalum, Solid Electrolyte, Established Reliability, (Style CSR) |
| MIL-C-39006 | Capacitors, Fixed Electrolytic, Tantalum, Non-solid Electrolyte, Established Reliability, (Style CLR) |
| MIL-C-39018 | Capacitors, Fixed, Electrolytic, Aluminum Oxide, (Style CU) |

VARIABLE CAPACITORS

| | |
|---|---|
| MIL-C-81 | Capacitors, Variable, Ceramic, (Style CV) |
| MIL-C-14409 | Capacitors, Variable, Piston Type, Tubular Trimmer, (Style PC) |

### 2.5.2.1 Fixed (Paper/Plastic) Film Capacitors

- Application - This group of capacitors has high insulation resistance, low dielectric absorption or low loss factor over wide temperature ranges with the AC component of impressed voltage ranging from small to more than 50% of the DC voltage rating. MIL-C-19978 capacitors are not recommended where heavy transient or pulse currents are encountered. MIL-C-55514 capacitors are not recommended for space application where degassing is not permitted.

- Derating - Ambient temperature and DC voltage are the principal stress parameters for fixed film capacitors. For MIL-C-11693 capacitors, the maximum line current should be 80% of the rated value. The derating levels are shown in Table 2.5-1.

TABLE 2.5-1: DERATING FOR CAPACITORS, FIXED FILM
DEFINED BY MIL-C-11693, MIL-C-19978,
MIL-C-39022, MIL-C-55514, MIL-C-83421

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| DC VOLTAGE (% OF RATED VALUE) | 50 | 60 | 60 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 10 | 10 | 10 |

2.5.2.2 Fixed Mica Capacitors

o Application - Due to the inherent characteristics of the dielectric, mica capacitors are small, have good stability and are highly reliable. MIL-C-10950 may fail from silver-ion migration if exposed to DC voltage stresses, humidity and high temperature.

o Derating - Ambient temperature and DC voltage are the principal stress parameters for fixed mica capacitors. The derating levels are shown in Table 2.5-2.

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| DC VOLTAGE (% OF RATED VALUE) | 50 | 60 | 60 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 10 | 10 | 10 |

### 2.5.2.3 Fixed Glass Capacitors

- o Application - Fixed glass capacitors have a low dissipation factor, high insulation resistance, high temperature stability and high frequency stability up to 500 Mhz.

- o Derating - Ambient temperature and DC voltage are the principal stress parameters for fixed glass capacitors. The derating levels are shown in Table 2.5-3.

TABLE 2.5-3: DERATING FOR CAPACITORS, FIXED GLASS DEFINED BY MIL-C-23269

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| DC VOLTAGE (% OF RATED VALUE) | 50 | 60 | 60 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 10 | 10 | 10 |

### 2.5.2.4 Fixed Ceramic Capacitors

- o Application - Excessive heat used in soldering the leads may damage the encapsulation and weaken the electrode to terminal lead contact.

- o Derating - Ambient temperature and DC voltage are the principal stress parameters for fixed ceramic capacitors. The derating levels are shown in Table 2.5-4.

TABLE 2.5-4: DERATING FOR CAPACITORS, FIXED CERAMIC DEFINED BY MIL-C-20, MIL-C-11015, MIL-C-39014

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| DC VOLTAGE (% OF RATED VALUE) | 50 | 60 | 60 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 10 | 10 | 10 |

2.5.2.5 Fixed Electrolytic (Aluminum) Capacitors

- o Application - Aluminum electrolytic capacitors provide the smallest volume, mass and cost per microfarad except for tantalum capacitors. These capacitors are not hermetically sealed and are not recommended for airborne equipment application since they should not be subjected to low barometric pressure and low temperature at high altitudes.

- o Derating - Ambient temperature and DC voltage are the principal stress parameters for fixed electrolytic capacitors. The initial surge current and ripple current should be 70% of maximum rated. The derating levels are shown in Table 2.5-5.

TABLE 2.5-5: DERATING FOR CAPACITORS, FIXED ALUMINUM ELECTROLYTIC DEFINED BY MIL-C-62, MIL-C-39018

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| DC VOLTAGE (% OF RATED VALUE) | NR* | NR | 80 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | NR | NR | 20 |

*NR - NOT RECOMMENDED

2.5 2.6 Fixed Electrolytic (Solid) Tantalum Capacitors

- o Application - A minimum circuit impedance of three ohms per applied volt should be utilized to attain improved reliability. These capacitors are not to be operated with reverse ripple current.

- o Derating - Ambient temperature and DC voltage are the principal stress parameters for fixed electrolytic tantalum capacitors. The initial surge current and ripple current should be 70% of maximum rated. The derating levels are shown in Table 2.5-6.

TABLE 2.5-6: DERATING FOR CAPACITORS, FIXED ELECTROLYTIC (SOLID) TANTALUM DEFINED BY MIL-C-39003

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| DC VOLTAGE (% OF RATED VALUE) | 50 | 60 | 60 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 20 | 20 | 20 |

2.5.2.7 Fixed Electrolytic (Nonsolid) Tantalum Capacitors

- Application - No reverse voltage should be permitted as the reverse voltage produces large currents and removal of silver into solution.

- Derating - Ambient temperature and DC voltage are the principal stress parameters for fixed electrolytic nonsolid tantalum capacitors. The initial surge current and ripple current should be 70% of maximum rated. The derating levels are shown in Table 2.5-7.

TABLE 2.5-7: DERATING FOR CAPACITORS, FIXED ELECTROLYTIC (NONSOLID) TANTALUM DEFINED BY MIL-C-39006

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| DC VOLTAGE (% OF RATED VALUE) | 50 | 60 | 60 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 20 | 20 | 20 |

2.5.2.8 Variable (Piston Type, Tubular, Trimmer) Capacitors

- Application - These capacitors are small, sealed, tubular trimmers designed for use where fine tuning adjustments are periodically required.

- Derating - Ambient temperature and DC voltage are the principal stress parameters for variable capacitors. The derating levels are shown in Table 2.5-8.

TABLE 2.5-8: DERATING FOR CAPACITORS, VARIABLE (PISTON TYPE, TUBULAR, TRIMMER) DEFINED BY MIL-C-14409

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| DC VOLTAGE (% OF RATED VALUE) | 40 | 50 | 50 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 10 | 10 | 10 |

2.5.2.9 Variable, Ceramic Capacitors

- Application - The temperature sensitivity is nonlinear over the capacitance range; therefore, these capacitors should not be designed into circuits as temperature compensating units.

- Derating - Ambient temperature and DC voltage are the principal stress parameters for variable ceramic capacitors. The derating levels are shown in Table 2.5-9.

TABLE 2.5-9: DERATING FOR CAPACITORS, VARIABLE CERAMIC DEFINED BY MIL-C-81

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| DC VOLTAGE (% OF RATED VALUE) | 30 | 50 | 50 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 10 | 10 | 10 |

## 2.6 Inductive Devices Derating Criteria

2.6.1 General - This section supplies the derating parameters and application guidelines for inductive devices. The reliability of inductive devices is a function of operating hot spot temperature as it relates to the insulation capability, operating current, in-rush transients, and dielectric stress. The method of computing the hot-spot temperature is given in MIL-HDBK-217D.

2.6.2 Inductor Types - The inductive device types covered in this section are: MIL-T-27, MIL-T-15305, MIL-T-21038, MIL-T-55631 and MIL-C-39010.

- o Application - The winding voltage should be kept at the nominal vendor specified value to prevent insulation breakdown which is the major failure mode for inductive devices. Operation at lower than designed frequency range should not be allowed as overheating and core saturation may result. The devices must be designed for the proper temperature range in which it is to operate.

- o Derating - Frequency and winding voltage are NOT derated. The parameters to be derated are hot spot temperature, maximum current, in-rush transients and dielectric stress and are shown in Table 2.6-1.

TABLE 2.6-1: DERATING FOR INDUCTORS

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| TEMPERATURE DERATING (FROM MAX HOT-SPOT) | 40 | 25 | 15 |
| OPERATING CURRENT (% OF RATED VALUE) | 60 | 60 | 60 |
| TRANSIENT VOLTAGE (% OF RATED VALUE) | 90 | 90 | 90 |
| DIELECTRIC WITHSTANDING VOLTAGE (% OF RATED VALUE) | 50 | 50 | 50 |

## 2.7 Relay Derating Criteria

2.7.1 General - This section supplies the derating parameters and application guidelines for relays.

2.7.2 Relay Types - Four major groups of relays are covered in this section and are: electromechanical relays, solid state relays, hybrid electro-mechanical and hybrid solid state relays.

- o Application - For mechanical relays the circuits to be switched should be designed to minimize stresses on the relay contacts. Nonresistive load switching requires arc suppression design techniques to protect relay contacts. Pure solid state relays have no mechanical contacts. When using nonresistive loads, surge current can create high junction temperatures resulting in degradation or failure of the relay.

o <u>Derating</u> - The principal parameters for relays are the continuous contact current, coil operating voltage and temperature. The derating guidelines are shown in Table 2.7-1.

TABLE 2.7-1: DERATING FOR RELAYS

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| RESISTIVE LOAD CURRENT (% OF RATED VALUE) | 50 | 75 | 75 |
| CAPACITIVE LOAD CURRENT (% OF RATED VALUE) | 50 | 75 | 75 |
| INDUCTIVE LOAD CURRENT (% OF RATED VALUE) | 35 | 40 | 40 |
| MOTOR LOAD CURRENT (% OF RATED VALUE) | 15 | 20 | 20 |
| LAMP (FILAMENT) LOAD CURRENT (% OF RATED VALUE) | 08 | 10 | 10 |
| CONTACT POWER (1) (% OF RATED VALUE) | 40 | 50 | 50 |
| COIL OPERATING VOLTAGE (% OF RATED VALUE) | 90 | 90 | 90 |
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 20 | 20 | 20 |

(1) Applicable to reed, mercury wetted or other loads rated in watt or volt amperes.

## 2.8 Switch Derating Criteria

2.8.1 <u>General</u> - This section supplies the derat. ] parameters and application criteria for switches.

2.8.2 <u>Switch Type</u> - Four major groups of switches are covered, and they are: toggle, sensitive, rotary and pushbutton.

o <u>Application</u> - Thermal and altitude variations must be considered as moisture may cause contact contamination or short circuits. Positive break toggle switches are preferred for high current levels. Sealed switches should be used in humid or dirty environments.

o Derating - The contact current, voltage and power are the principal stress parameters. The derating levels are listed in Table 2.8-1.

TABLE 2.8-1: DERATING FOR SWITCHES

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| RESISTIVE LOAD CURRENT (% OF RATED VALUE) | 50 | 75 | 75 |
| CAPACITIVE LOAD CURRENT (% OF RATED VALUE) | 50 | 75 | 75 |
| INDUCTIVE LOAD CURRENT (% OF RATED VALUE) | 30 | 40 | 40 |
| MOTOR LOAD CURRENT (% OF RATED VALUE) | 15 | 20 | 20 |
| LAMP (FILAMENT) LOAD CURRENT (% OF RATED VALUE) | 08 | 10 | 10 |
| CONTACT POWER (1) (% OF RATED VALUE) | 40 | 50 | 50 |
| CONTACT VOLTAGE (% OF RATED VALUE) | 40 | 50 | 50 |

(1) When contacts are rated for power or volt-ampere capacity such as with reed switches or mercury switch.

## 2.9 Connector Derating Criteria

2.9.1 General - The primary factors affecting the failure rate of connectors are insert material, contact current, number of active contacts, mate and unmate cycling and the environment in which it is operated. The rating of a connector is determined by the temperature of the insert material.

2.9.2 Connector Types - Three classes of connectors are covered in this section and they are: circular, printed wire board and coaxial.

o Application - Scoop-proof connectors should be considered for designs susceptible to bent pin failures. When pins are connected in parallel at the connector to increase the current capacity, allow for a minimum of 25% surplus of pins over that required to meet the 50% derating for each pin.

o Derating - Voltage, current and temperature are the stress parameters that will be derated for connectors. The derating levels are shown in Table 2.9-1.

TABLE 2.9-1: DERATING FOR CONNECTORS

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| AC/DC VOLTAGE (% OF RATED VALUE) | 50 | 70 | 70 |
| CURRENT (% OF RATED VALUE) | 50 | 70 | 70 |
| INSERT TEMPERATURE DERATING (°C) (1) (FROM MAX LIMIT) | 50 | 25 | 25 |

(1) Ambient temperature is that temperature in which the connector will operate. Heating factor is the temperature rise caused by power transmission through the contacts.

## 2.10 Rotating Device Derating Criteria

2.10.1 General - The bearing load, winding temperature and the ambient temperature of operation are the principal stress factors for rotating devices.

2.10.2 Rotating Device Types - The types covered in this section are: motors, synchros, resolvers and motor driven elapsed time meters.

o Application - Escessive loads or low speed can create high winding temperature, and excessive bearing loads. Moisture should be minimized to prevent corrosion, insulation degradation and low resistance to electrical leakage.

o Derating - Operating temperature and bearing load are the parameters to be derated. The levels are shown in Table 2.10-1.

TABLE 2.10-1: DERATING FOR ROTATING DEVICES

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| TEMPERATURE DERATING (°C) (FROM MAX LIMIT) | 40 | 25 | 15 |
| BEARING LOAD (% OF RATED VALUE) | 75 | 90 | 90 |

## 2.11 Lamp Derating Criteria

2.11.1 General - The selected derating levels in this section are based upon review of historical applications and engineering judgment to balance the increased reliability against the relative constraints placed upon design freedom.

2.11.2 Lamp Types - This section will cover the derating for incandescent and gaseous (neon-argon) lamps.

### 2.11.2.1 Incandescent Lamps

- Application - Incandescent lamps should not be exposed to extreme shock or vibration near the resonant frequency of the filament. Temperature cycling is damaging to incandescent lamps.

- Derating - The derating for all three levels is 94% of the rated voltage if operated in normal environments. This derating will double the life of the lamp with only a 16% drop in light output.

### 2.11.2.2 Neon Lamp

- Application - The starting and sustaining voltage levels are lamp characteristics and cannot be derated. The starting voltage level can be increased for a quicker response time, but the life expectancy will be decreased.

- Derating - Current through the lamp is the principal stress parameter. The current derating for all three levels is 94% of the rated current. With a derating of 94%, the life expectancy will double and the output will only be decreased by 16%.

## 2.12 Circuit Breaker Derating Criteria

2.12.1 General - Current through a circuit breaker is the principal derating stress parameter. The current derating for Level I is 75% of the rated level and for Levels II and III, use 80% of the rated level. At these levels, the ability to protect the circuit from a large overload is still available.

## 2.13 Fuse Derating Criteria

2.13.1 General - Current is the principal derating stress parameter for fuses. The current derating for fuses is 50% of the rated value for Levels I, II, and III. There is an additional derating of 0.5%°C for an increase in the ambient temperature above 25°C. Derating of the fuse voltage is 20-40% for fuse current ratings of 1/2 A or less.

## 2.14 Crystal Derating Criteria

2.14.1 General - The driving power for most crystal units cannot be derated since the rated frequency may not be obtainable. Consult the appropriate specification or manufacturer's literature for possible exceptions. The operating temperature of the crystal must be maintained between the maximum and minimum limits in order to achieve the rated frequency.

## 2.15 Tube Derating Criteria

2.15.1 General - The derating levels selected in this section are based upon engineering judgment by consideration of the device construction and materials. In many cases, due to the operative nature of the devices, derating itself is inappropriate. However, where practical, the design should strive to give the maximum stress margin (below maximum rated) practical when considered against the design difficulties thus incurred.

2.15.2 Tube Types - This section covers cathode ray tubes and microwave tubes of the followng types; traveling wave tubes, magnetrons and klystrons.

### 2.15.2.1 Cathode Ray Tube

- Application and Derating - The design of systems using cathode ray tubes is highly dependent on human factors such as visibility, size, color, readability, etc. Because of the specialized nature of the design field and of the data, it is not practical to establish generalized application and derating

guidelines. However, with vacuum tube devices, the bulb, and the cathode temperatures are important for reliability. Consult specifications and manufacturer's literature for the optimum conditions for minimum failure rates. Also, consideration can be given to maintaining cathode temperature at a reduced temperature during "off" conditions. This will reduce effects of cold in-rush current and thermal cycling. Most failures are associated with cathode failure due to thermal effects or gun assembly failure due to mechanical stresses from vibration or shock.

### 2.15.2.2 Microwave Tube

- o Application - The design usage of microwave tubes is highly specialized and there is insufficient data to define derating guidelines for all conditions. Use the failure rate prediction methods of MIL-HDBK-217D to optimize design and usage for minimum failure rate.

- o Derating - The derating parameters for all levels are shown in Table 2.15-1.

TABLE 2.15-1: DERATING FOR MICROWAVE TUBES

| | LEVELS I, II & III |
|---|---|
| TEMPERATURE DERATING (°C) RATING (FROM MAX LIMIT) | 20 |
| POWER OUTPUT (% OF RATED VALUE) | 80 |
| REFLECTED POWER (% OF RATED VALUE) | 50 |
| DUTY CYCLE (% OF RATED VALUE | 75 |

## 2.16 Laser Derating Criteria

2.16.1 General - Laser system design is a specialized field where the operating parameters of each type are unique and interdependent. Develop designs for minimum predicted failure rate using the failure rate models of MIL-HDBK-217D and follow manufacturer's recommendations for operating parameters and conditions not defined by the failure rate models.

## 2.17 Vibration Derating Criteria

2.17.1 General - Vibrators are not recommended for use in electrical circuits because of limited cycling life. If a vibrator device is needed, the use of a solid state device like a high power switching transistor, is recommended.

## 2.18 Surface Acoustical Wave Device Derating Criteria

2.18.1 General - Derate input power by +10 dBm for devices operating above 100 MHz and +20 dBm for devices operating below 100 MHz. The design should not subject the SAW devices to the rated maximum of shock, vibration and temperature cycling.

## 2.19 Fiber Optic Components Derating Criteria

2.19.1 General - The two major source types, light emitting diodes (LEDs) and injection laser diodes (ILDs), share most of the failure mechanisms and stress factors. Application choice of the two device types is dependent on two parameters: optical power and bandwidth. ILDs are capable of coupled power to the fiber in the range of a few milliwatts and bandwidths in the low gigahertz region while LEDs are generally capable of only a few hundred microwatts of coupled power and a bandwidth in the order of a few hundred megahertz.

2.19.2 Fiber Optic Component Types - The component types covered in this section are: optical sources, optical detectors, cables and connectors.

### 2.19.2.1 Optical Sources (ILD and LED)

- Application - Power supplies for ILDs must be designed to eliminate overcurrent pulses which can cause catastrophic failure by facet damage. Output power should be given a 3dB margin to account for gradual degradation. Thermal or mechanical shock cause dark line defects (crystal lattice defects) to grow and will reduce output power. Stress screening should be used to eliminate devices with dark line defects.

- Derating - Primary stress factors for optical sources are temperature (ILD and LED) voltage-current power dissipation (LED), and optical power dissipation (ILD). The recommended derating factors are shown in Table 2.19-1.

TABLE 2.19-1: DERATING FOR OPTICAL SENSORS

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) (FOR LED & ILD) | 95 | 105 | 110 |
| AVERAGE FORWARD CURRENT (% OF RATED VALUE) (FOR LED) | 50 | 65 | 75 |
| POWER OUTPUT (% OF RATED VALUE) (FOR ILD) | 50 | 60 | 70 |

2.19.2.2 Optical Detectors (PIN and Avalanche Photo Diodes)

- Application - Power derating is not necessary because internal dissipation is not significant. Reverse voltage cannot be derated for the avalanche photo diode (APD) as the voltage is used to set or adjust device gain and is typically set slightly below the breakdown voltage.

- Derating - The primary stress factors for optical detectors are temperature (PIN & APD) and reverse voltage for PIN diodes. The recommended derating factors are shown in Table 2.19-2.

TABLE 2.19-2: OPTICAL DETECTOR DERATING

| | LEVEL I | LEVEL II | LEVEL III |
|---|---|---|---|
| MAXIMUM JUNCTION TEMPERATURE (°C) (FOR PIN & APD) | 95 | 105 | 125 |
| REVERSE VOLTAGE (% OF RATED VALUE) (FOR PIN) | 70 | 70 | 70 |

2.19.2.3 Fiber Optic Cables

- Application - Cable construction is the key to high reliability in the particular applications of fiber optic cables. The use of strength members, buffers, jackets, and moisture barriers in the development of optimum cable designs should be considered. New products procured under specification control for use outside of known performance levels should be qualified before use.

- Derating - Primary stress factors should be derated as follows:

  Temperature: 20°C inside both upper and lower limits.

  Tension fiber: 20% of proof test.

  Tension cable: 50% of the rated tensile.

  Bend radius: 200% of minimum.

2.19.2.4 Fiber Optic Connectors

- Application and Derating - The primary degrading environment is temperature. See derating for conventional connectors for derating guidelines.

APPENDIX A

CONTRACTUAL REQUIREMENTS FOR DERATING

1. Introduction - Derating can be contractually required by two insertions in the contract specification and subsequently in all development CI specifications.

2. Design Requirements - In accordance with the requirements of MIL-STD-490, and consistent with current practice, derating will be addressed in specification paragraph 3.3.1, "Materials, Processes, and Parts." The subparagraph which is entitled "Parts" (i.e., usually 3.3.1.3 or 3.3.1.4) will have subparagraphs as follows:

3.3.1.X.1 Derated Application of Parts
3.3.1.X.2 Parts Selection

Therefore, the request for proposal specification, will have a specification pargraph as follows:

"3.3.1.X.1 Derated Application of Parts. The design of parts into equipments shall comply with a government-approved, contractor derating standard or with derating level (to be selected by the government program office) of ESD TR-83-197."

The contractor will provide his derating standard with his proposal. ESD technical staff and RADC/RB will advise the program office as to whether the contractor standard is satisfactory or is inconsistent with the ESD TR. The contract specification will then incorporate either the selected contractor standard or the ESD TR with defined derating level. All contractor-generated development (i.e. type B) specifications shall include the same paragraph for derating.

Criteria for selection of the appropriate criticality level is defined in section 1.2. The following is further guidance:

| Application Category | Derating Level Minimum | Derating Level Maximum |
|---|---|---|
| Spaceborne | I | I |
| Avionics | II | I |
| $C^3$ (ground or airborne) | III | I |
| Large Missiles (e.g. ballistic) | II | I |
| Small Missiles | III | I |

3. Verification Requirements - Section 4 of all specifications for newly developed equipments and for development modifications of off-the-shelf equipments shall require verification of specification paragraph 3.3.1.X.1 by "test" in accordance with ESD-TR-83-197, Appendix B. Reliability of unmodified off-the-shelf equipments will be verified to comply with specification paragraph 3.2.3, "Reliability", by analysis of field data. If such field data is inadequate, the original design and test data for derating should be analyzed.

APPENDIX B

DERATING VERIFICATION REQUIREMENTS

1. Verifications will be conducted to assure that parts are operating within the specified derated values.

2. Contractors are encouraged to perform extensive testing during engineering test and evaluation and preliminary qualification.

3. Government-monitored, formal-qualification testing will be performed in accordance with the contractor-prepared, government-approved test plan.

4. The following are minimum requirements for the test plan:

a. All derated parameters will be verified for ten percent of the total parts in each developed equipment. This will include more than six percent of the active parts and more than two percent of the passive parts.

b. The contactor will identify the more critical parts to be verified using the following criteria:

(1) The specified and designed derating are closer to the design limit for the part.

(2) High failure rate parts will be identified by using MIL-HDBK-217D or other data or by tests on early equipment design models.

(3) More highly stressed circuits or equipment locations have been determined by analyses or other means. While this criteria is more oriented toward thermal hot-spots analyses and surveys, it also applies to electrical properties.

(4) The parts to be verified shall be distributed throughout the equipment.

c. The contractor-prepared test plan will list all parts identified to be critical by the above criteria. The recommended parts to be verified by test will then be identified from this list. The rationale for the selection of each part will be provided in the test plan.

d. The test plan will define the methods for measuring each derated parameter and the analysis which is necessary to compare the measured to the specified value. This is anticipated to be straight-forward for all parameters except semiconductor junction temperature. If part vendor data is not available to relate the temperature at a measurable external point to the junction temperature, MIL-HKBK-217D, figure 6, page C-14, will be used. The equipment containing each part will be operated at the worst case environment, duty cycle and load, when such has an effect on a derated parameter for that part.

e. During the test plan approval process, the government may challenge the validity of test methods and may substitute other parts for verification not to exceed five percent of all parts.

APPENDIX C

DERATING CRITERIA SUMMARY

4.1 General - This section provides a summary of most of the parts and stress parameters for quick reference. The detailed factors for each part are contained in Section 2. The summary is shown in Table 4-1.

TABLE 4-1: DERATING CRITERIA SUMMARY

| | | MAXIMUM ALLOWABLE ABSOLUTE VALUE OR PERCENT OF RATED VALUE | | |
|---|---|---|---|---|
| PART TYPE | DERATING PARAMETER | LEVEL I | LEVEL II | LEVEL III |
| MICROCIRCUITS | | | | |
| o Linear (Bipolar & MOS) | Supply Voltage | 70% | 80% | 80% |
| | Input Voltage | 60% | 70% | 70% |
| | Output Current | 70% | 75% | 80% |
| | Max $T_j$ (°C) | 80 | 95 | 105 |
| o Digital (Bipolar) | Supply Voltage | +/-3% | +/-5% | +/5% |
| | Frequency | 80% | 90% | 95% |
| | Output Current | 80% | 85% | 90% |
| | Max $T_j$ (°C) | 85 | 100 | 110 |
| o Digital (MOS) | Supply Voltage | 70% | 85% | 85% |
| | Frequency | 80% | 80% | 90% |
| | Output Current | 80% | 85% | 90% |
| | Max $T_j$ (°C) | 85 | 100 | 110 |
| o Hybrid | Thick film power density | 50w/in$^2$ | 50w/in$^2$ | 50w/in$^2$ |
| | Thin film power density | 40w/in$^2$ | 40w/in$^2$ | 40w/in$^2$ |
| | Max $T_j$ (°C) | 85 | 100 | 110 |
| TRANSISTORS | | | | |
| o Bipolar (NPN & PNP) | Power Dissipation | 50% | 60% | 70% |
| | Breakdown Voltage | 60% | 70% | 70% |
| | Safe Operating Area | 70%$V_{ce}$ 60%$I_c$ | 70%$V_{ce}$ 60%$I_c$ | 70%$V_{ce}$ 60%$I_c$ |
| | Max $T_j$ (°C) | 95 | 105 | 125 |
| o Field-Effect (P Channel & N Channel) | Power Dissipation | 50% | 60% | 70% |
| | Breakdown Voltage | 60% | 70% | 70% |
| | Max $T_j$ (°C) | 95 | 105 | 125 |

| | | MAXIMUM ALLOWABLE ABSOLUTE VALUE OR PERCENT OF RATED VALUE | | |
|---|---|---|---|---|
| PART TYPE | DERATING PARAMETER | LEVEL I | LEVEL II | LEVEL III |
| o Thyristors (SCR & Triac) | On-State Current ($I_t$) | 50% | 70% | 70% |
| | Off-State Voltage (VDM) | 70% | 70% | 70% |
| | Max $T_j$ (°C) | 95 | 105 | 125 |
| DIODES | | | | |
| o Axial Lead (Small Signal/ Switch) | Forward Current | 50% | 65% | 75% |
| | Reverse Voltage | 70% | 70% | 70% |
| | Max $T_j$ (°C) | 95 | 105 | 125 |
| (Schottky/PIN) | Power Dissipation | 50% | 60% | 70% |
| | Reverse Voltage | 70% | 70% | 70% |
| | Max $T_j$ (°C) | 95 | 105 | 125 |
| o Power Rectifier | Forward Current | 50% | 65% | 75% |
| | Reverse Voltage | 70% | 70% | 70% |
| | Max $T_j$ (°C) | 95 | 105 | 125 |
| o Voltage | | | | |
| - Regulator | Power Dissipation | 50% | 60% | 70% |
| | Max $T_j$ (°C) | 95 | 105 | 125 |
| - Reference | Current $I_{zt}$ | Fixed Test | Fixed Test | Fixed Test |
| | Max $T_j$ (°C) | 95 | 105 | 125 |
| o Transient Suppressor | Power Dissipation | 50% | 60% | 70% |
| | Average Current | 50% | 65% | 75% |
| | Max $T_j$ (°C) | 95 | 105 | 125 |
| o Microwave | Power Dissipation | 50% | 60% | 70% |
| | Reverse Voltage | 70% | 70% | 70% |
| | Max $T_j$ (°C) | 95 | 105 | 125 |
| o LED | Forward Current | 50% | 65% | 75% |
| | Max $T_j$ (°C) | 95 | 105 | 110 |
| RESISTORS | | | | |
| o Composition | Power/Temp (°C)(1) | 50%/30 | 50%/30 | 50%/30 |
| o Film | Power/Temp (°C) | 50%/40 | 50%/40 | 50%/40 |
| o Wirewound | | | | |
| Accurate | Power/Temp (°C) | 50%/10 | 50%/10 | 50%/10 |
| Power | Power/Temp (°C) | 50%/125 | 50%/125 | 50%/125 |
| o Variable | | | | |
| Wirewound | Power/Temp (°C) | 30%/45 | 50%/35 | 50%/35 |
| Non-Wire | Power/Temp (°C) | 30%/45 | 50%/35 | 50%/35 |
| o Thermistor | Power/Temp (°C) | 50%/20 | 50%/20 | 50%/20 |

(1) Derating from Maximum Rated Temperature

| | | MAXIMUM ALLOWABLE ABSOLUTE VALUE OR PERCENT OF RATED VALUE | | |
|---|---|---|---|---|
| PART TYPE | DERATING PARAMETER | LEVEL I | LEVEL II | LEVEL III |
| <u>CAPACITORS</u> | | | | |
| o Film | Voltage/Temp (°C)(1) | 50%/10 | 60%/10 | 60%/10 |
| o Mica | Voltage/Temp (°C) | 50%/10 | 60%/10 | 60%/10 |
| o Glass | Voltage/Temp (°C) | 50%/10 | 60%/10 | 60%/10 |
| o Ceramic | Voltage/Temp (°C) | 50%/10 | 60%/10 | 60%/10 |
| o Electrolytic | | | | |
| Aluminum | Voltage/Temp (°C) | NR (2) | NR | 80%/20 |
| Tantalum (Solid) | Voltage/Temp (°C) | 50%/20 | 60%/20 | 60%/20 |
| Tantalum (Non) | Voltage/Temp (°C) | 50%/20 | 60%/20 | 60%/20 |
| o Variable | | | | |
| Piston | Voltage/Temp (°C) | 40%/10 | 50%/10 | 50%/10 |
| Ceramic | Voltage/Temp (°C) | 30%/10 | 50%/10 | 50%/10 |
| <u>INDUCTORS</u> | | | | |
| o Pulse | Operating Current | 60% | 60% | 60% |
| (XRFMS) | Dielectric Voltage | 50% | 50% | 50% |
| | Temp (°C) (Hot Spot) | 40 | 25 | 15 |
| o Coils | Operating Current | 60% | 60% | 60% |
| | Dielectric Voltage | 50% | 50% | 50% |
| | Temp (°C) (Hot Spot) | 40 | 25 | 15 |
| <u>RELAYS</u> | | | | |
| | Current (Resistive) | 50% | 75% | 75% |
| | Current (Capacitive) | 50% | 75% | 75% |
| | Current (Inductive) | 35% | 40% | 40% |
| | Current (Motor) | 15% | 20% | 20% |
| | Current (Lamp) | 8% | 10% | 10% |
| | Contact Power | 40% | 50% | 50% |
| | Temp (°C) | 20 | 20 | 20 |
| <u>SWITCHES</u> | | | | |
| | Current (Resistive) | 50% | 75% | 75% |
| | Current (Capacitive) | 50% | 75% | 75% |
| | Current (Inductive) | 35% | 40% | 40% |
| | Current (Motor) | 15% | 20% | 20% |
| | Current (Lamp) | 8% | 10% | 10% |
| | Contact Power | 40% | 50% | 50% |
| <u>CONNECTORS</u> | | | | |
| | Operating Voltage | 50% | 70% | 70% |
| | Operating Current | 50% | 70% | 70% |
| | Insert Temp (°C) | 50 | 25 | 25 |

(1) Derating from Maximum Rated Temperature
(2) NR - Not Recommended

| | | MAXIMUM ALLOWABLE ABSOLUTE VALUE OR PERCENT OF RATED VALUE | | |
|---|---|---|---|---|
| PART TYPE | DERATING PARAMETER | LEVEL I | LEVEL II | LEVEL III |
| <u>ROTATING</u> | | | | |
| | Bearing Load | 75% | 90% | 90% |
| | Operating Temp (°C)(1) | 40 | 25 | 15 |
| <u>LAMPS</u> | | | | |
| o Incandescent | Voltage | 94% | 94% | 94% |
| o Neon | Current | 94% | 94% | 94% |
| <u>CIRCUIT BREAKERS</u> | | | | |
| | Current | 75% | 80% | 80% |
| <u>FUSES</u> | | | | |
| | Current | 50% | 50% | 50% |
| <u>TUBES</u> | | | | |
| o Microwave | Power Output | 80% | 80% | 80% |
| | Power Reflected | 50% | 50% | 50% |
| | Duty Cycle | 75% | 75% | 75% |
| <u>FIBER OPTICS</u> | | | | |
| o ILD | Power Output | 50% | 60% | 70% |
| | Max $T_j$ (°C) | 95 | 105 | 110 |
| o APD | Max $T_j$ (°C) | 95 | 105 | 125 |
| o Cable | Bend Radius | 200 | 200 | 200 |
| | Tension Cable (2) | 50% | 50% | 50% |
| | Tension Fiber (3) | 20% | 20% | 20% |

(1) Derating from Maximum Rated Temperature
(2) Rated Tensile
(3) Proof Test